REPORT OF COOPERATIVE RESEARCH ON INSECT CONTROL IN FARM STORED GRAIN

No. 11 Period--January 1 to March 31, 1944

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The material in this report consists largely of unpublished data ~~and should be kept confidential~~. It is made available in its present form for the convenience of the various State and Federal Agencies concerned with the preservation of stored grain from insect damage.

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Memo
6/9/54
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6/10/54

WHEAT STORAGE

Condition of Wheat in Storage at Experimental Sites*

During January and February, the regular quarterly samples were taken from the bins on the experimental storage sites at both Jamestown, North Dakota, and Hutchinson, Kansas. Insect infestation was determined from the examination of average samples taken from each bin.

A comparison of the infestation at the two sites since their establishment in 1941 is given in table 1. At Jamestown insect populations have remained consistently at a very low level throughout the storage period, while at Hutchinson, insect infestation has been the major problem in connection with the safe storage of wheat.

* - Reported by H. H. Walkden and R. B. Schwitzgebel, U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine in Cooperation with the Bureau of Plant Industry, Soils and Agr. Engineering.

Table 1: -- Comparison of the insect infestation in wheat stored at Jamestown, North Dakota, and at Hutchinson, Kansas, October 1941 to February 1944.

Sampling period	Jamestown, North Dakota				Hutchinson, Kansas			
	No. bins sampled	Weevily bins (%)	Infested, not weevily (%)	Total infested (%)	No. bins sampled	Weevily bins (%)	Infested, not weevily (%)	Total infested (%)
1941								
Oct.-Nov.	139	1	18	19	144	9	31	40
1942								
Jan.-Feb.	133	1	6	7	135	16	53	69
Apr.-May	139	0	4	4	135	2	59	61
July-Aug.	142	0	6	6	124	0	43	43
Oct.-Nov.	146	0	1	1	133	58	21	79
1943								
Jan.-Feb.	152	0	0	0	144	33	21	54
Apr.-May	164	0	0.6	0.6	148	5	26	31
July-Aug.	166	0	2.5	2.5	114	60	26	86
Oct.-Nov.	132	0.8	0.8	1.6	165	46	43	89
1944								
Jan.-Feb.	165	1.3	1.3	2.6	161	6	65	71

Only two species were found in the February samples from Jamestown, the rust-red grain beetle (<u>Laemophloeus ferrugineus</u> Steph.) and the sawtooth grain beetle (<u>Oryzaephilus surinamensis</u> L.). The six species found at Hutchinson are listed below together with their comparative abundance.

Species	Average number per 1000 gram sample
1. Flat grain beetle (<u>Laemophloeus minutus</u> Oliv.).........	0.64
2. Red flour beetle (<u>Tribolium castaneum</u> Hbst.)...........	0.37
3. Rice weevil (<u>Sitophilus oryza</u> L.)......................	0.37
4. Lesser grain borer (<u>Rhyzopertha dominica</u> F.)...........	0.32
5. Sawtooth grain beetle (<u>Oryzaephilus surinamensis</u> L.)...	0.16
6. Long-headed flour beetle (<u>Lathelicus oryzae</u> Waterh.)...	0.07

Winter Distribution of Insect Populations in Stored Wheat

In order to further the study of the intra-bin distribution of insect populations, a separate examination of each of the individual probe samples composing the average sample was made at the time of the January quarterly sampling at Hutchinson. The results of the examinations are presented in tables 2, 3, and 4. A total of 161 bins were sampled but the 46 bins in which no insects were found are not included in the tables.

The intensities of infestation ranged from zero to 53.8 insects per 1000-gram sample in the 1000 bushel steel bins; zero to 3.7 in 1500 bushel wood bins; zero to 27.4 in 2740 bushel steel bins.

In 1000 bushel steel bins, 72 percent of the insects were taken in the south portion of the grain mass while in the 1500 bushel wood bins 59 percent of the total insects were taken in the center portion of the bin. Seventy-five percent of the insects in the wood bins were found in the upper half of the grain. In 2740 bushel steel bins 45 percent of the insects were taken in the center and 45 percent in the south portion of the grain. Approximately 57 percent of the total number of insects were found in the lower half of the bin.

The fact that more than half of the insects in the 2740 bushel bins were taken in the lower half of the bin is probably a result of fumigation. In previous observations most of the insects were found in the upper portions of the grain. These data are affected materially by the records from three bins which were fumigated with inadequate dosages resulting in the survival of large insect populations in the lower part of each bin.

Table 2: -- Intensity of infestation in individual probe samples composing the 5-probe average sample. 1000, 1250, and 2000 bushel steel bins. Hutchinson, Kansas, January, 1944.

Legend: * - 1250 bu. bins
** - 2000 bu. bins

	Location and number of insects per 1000-gram sample						
Bin No.	Center	North	East	South	West	Total	Average
2-2	2	51	3	186	27	269	53.8
3-16	0	0	0	203	0	203	40.6
10-7 **	3	0	0	56	0	59	11.8
3-10	24	5	3	24	1	57	11.4
12-12	5	5	0	21	0	31	6.2
½-10	3	0	1	13	5	22	4.4
1-12	5	0	0	9	1	15	3.0
1-13	1	0	1	10	1	13	2.6
3-5	2	1	0	10	0	13	2.6

Bin No.	Center	North	East	South	West	Total	Average
	Location and number of insects per 1000-gram sample						
3-2	6	2	2	2	0	12	2.4
3-3	3	0	0	5	2	10	2.0
½-9	2	1	1	4	1	9	1.8
4-16	3	1	1	4	0	9	1.8
4-15 *	0	0	0	8	0	8	1.6
3-11	4	0	0	1	2	7	1.4
1-10	1	0	0	6	0	7	1.4
11-12	4	0	0	2	0	6	1.2
1-11	2	1	1	2	0	6	1.2
1-7	2	0	0	2	1	5	1.0
2-6	0	0	0	5	0	5	1.0
2-11	0	2	2	1	0	5	1.0
1-4	0	0	5	0	0	5	1.0
½-7	1	1	0	3	0	5	1.0
½-8	1	0	0	4	0	5	1.0
3-1	2	0	2	0	0	4	0.8
4-3	0	0	2	0	2	4	0.8
10-12	1	0	0	3	0	4	0.8
10-8 **	2	0	0	2	0	4	0.8
2-14	0	0	0	3	0	3	0.6
2-9	0	0	0	3	0	3	0.6
1-1	0	0	0	3	0	3	0.6
2-13	2	0	0	1	0	3	0.6
½-2	0	1	0	0	1	2	0.4
1-2	0	0	1	0	1	2	0.4
1-3	1	0	0	0	1	2	0.4
1-15	0	1	0	1	0	2	0.4
2-4	0	0	0	2	0	2	0.4
3-4	0	0	0	2	0	2	0.4
3-6	1	0	0	1	0	2	0.4
4-7	2	0	0	0	0	2	0.4
4-9	1	0	0	1	0	2	0.4
4-13	1	0	0	1	0	2	0.4
1-9	0	0	0	1	0	1	0.2
1-14	1	0	0	0	0	1	0.2
2-8	1	0	0	0	0	1	0.2
2-12	0	0	0	1	0	1	0.2
3-7	1	0	0	0	0	1	0.2
3-17 *	0	1	0	0	0	1	0.2
3-15	1	0	0	0	0	1	0.2
4-6	0	0	0	1	0	1	0.2
4-12	1	0	0	0	0	1	0.2
12-11	0	0	0	0	1	1	0.2
Totals	92	73	25	607	47	844	
Percent of total	10.9	8.6	3.0	71.9	5.6		

Table 3:--Intensity of infestation in individual probe samples composing the 10-probe average sample from 2740, 4000, and 5000 bushel steel bins, Hutchinson, Kansas, January, 1944.

Legend: * - 4000 bu. bins; ** - 5000 bu. bins

Bin	Locations and numbers of insects per 1000 grams												
	Center		North		East		South		West		Totals		Ave.
No.	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	sample
11-7	7	0	0	0	0	0	103	162	2	0	112	162	27.4
8-1	0	0	0	0	0	0	29	143	0	0	29	143	17.2
12-2	1	166	0	0	0	0	2	0	0	0	3	166	16.9
8-9	32	6	2	0	0	0	33	10	45	0	112	16	12.8
8-8	39	18	2	0	1	0	4	0	0	25	46	43	8.9
10-5	32	0	0	0	1	0	0	13	1	0	34	13	4.7
7-8	3	36	0	0	0	0	0	0	2	1	5	37	4.2
8-7	0	36	0	0	0	0	0	0	0	0	0	36	3.6
10-10	14	9	0	0	0	0	6	4	0	0	20	13	3.3
12-1	10	6	1	2	2	1	0	0	1	1	14	10	2.4
5-11*	11	8	3	0	0	0	1	0	0	0	15	8	2.3
8-4	5	11	0	3	0	0	0	1	0	1	5	16	2.1
7-5	1	5	0	0	1	0	0	13	0	0	2	18	2.0
8-5	12	3	0	0	0	0	1	1	0	0	13	4	1.7
11-2	0	5	0	1	0	1	4	4	0	0	4	11	1.5
7-10	9	0	0	0	0	0	3	2	0	0	12	2	1.4
12-8	10	2	1	0	0	0	0	0	1	0	12	2	1.4
6-8	0	0	0	0	0	1	6	7	0	0	6	8	1.4
6-2	8	1	0	0	1	0	1	1	1	0	11	2	1.3
5-1	1	0	1	0	1	0	4	2	3	0	10	2	1.2
5-2	9	2	0	0	1	0	0	0	0	0	10	2	1.2
6-13*	4	5	2	0	0	1	0	0	0	0	6	6	1.2
11-4	0	0	0	0	0	0	11	0	0	0	11	0	1.1
5-3	6	0	3	0	0	0	1	0	0	0	10	0	1.0
6-5	0	0	1	0	1	0	5	0	0	1	7	1	0.8
12-7	5	1	0	0	0	0	0	0	0	2	5	3	0.8
11-9	0	7	0	0	0	0	0	0	0	0	0	7	0.7
7-4	2	5	0	0	0	0	0	0	0	0	2	5	0.7
5-10**	0	0	0	0	0	0	2	5	0	0	2	5	0.7
6-9	3	1	0	0	0	1	0	1	0	0	3	3	0.6
9-11	2	3	0	0	0	0	1	0	0	0	3	3	0.6
8-6	3	1	0	0	0	0	1	0	0	0	4	1	0.5
9-12	5	0	0	0	0	0	0	0	0	0	5	0	0.5
11-1	0	0	0	0	0	0	1	3	0	0	1	3	0.4
7-9	2	1	0	0	0	0	1	0	0	0	3	1	0.4
9-6	4	0	0	0	0	0	0	0	0	0	4	0	0.4
5-4	0	0	0	0	0	0	3	0	1	0	4	0	0.4
5-9	0	1	0	2	0	0	1	0	0	0	1	3	0.4
5-5	0	0	0	0	0	0	4	0	0	0	4	0	0.4
7-1	0	4	0	0	0	0	0	0	0	0	0	4	0.4
7-11	1	3	0	0	0	0	0	0	0	0	1	3	0.4
6-6	0	0	0	0	0	0	3	0	0	0	3	0	0.3

Bin No.	Center Upper	Center Lower	North Upper	North Lower	East Upper	East Lower	South Upper	South Lower	West Upper	West Lower	Totals Upper	Totals Lower	Ave. sample
	Locations and numbers of insects per 1000 grams												
9-7	0	0	0	0	0	0	0	1	1	1	1	2	0.3
6-7	1	0	0	0	1	0	1	0	0	0	3	0	0.3
6-4	0	0	0	0	0	0	2	0	0	0	2	0	0.2
7-7	0	0	1	0	0	0	0	0	0	0	1	0	0.1
9-4	0	0	0	0	0	0	1	0	0	0	1	0	0.1
5-8	1	0	0	0	0	0	0	0	0	0	1	0	0.1
7-3	1	0	0	0	0	0	0	0	0	0	1	0	0.1
9-10	0	0	0	0	0	0	0	1	0	0	0	1	0.1
11-6	0	0	0	0	0	0	1	0	0	0	1	0	0.1
8-10	1	0	0	0	0	0	0	0	0	0	1	0	0.1
12-9	0	0	0	0	0	0	1	0	0	0	1	0	0.1
Totals	245	346	17	7	10	5	237	374	58	32	567	764	
Percent of total	18.4	26.0	1.3	0.5	0.8	0.4	17.8	28.1	4.4	2.4	42.6	57.4	

Table 4:--Intensity of infestation in individual probe samples composing the 6-probe average sample, 1500-bushel wooden bins, Hutchinson, Kansas, January, 1944.

Bin No.	North Upper	North Lower	Center Upper	Center Lower	South Upper	South Lower	Total Upper	Total Lower	Total	Average
	Locations and numbers of insects per 1000 grams									
13-7	1	1	2	2	5	0	8	3	11	3.7
13-8	0	0	1	5	2	0	3	5	8	2.7
13-4	4	0	0	0	2	0	6	0	6	2.0
13-2	0	0	5	0	0	0	5	0	5	1.7
13-1	0	0	4	0	0	0	4	0	4	1.3
13-3	0	0	2	0	0	0	2	0	2	0.7
13-5	0	0	0	0	1	1	1	1	2	0.7
13-9	0	0	2	0	0	0	2	0	2	0.7
13-10	0	1	0	1	0	0	0	2	2	0.7
13-6	0	0	1	0	0	0	1	0	1	0.3
13-11	0	0	0	0	0	0	0	0	0	0
Totals	5	2	17	8	10	1	32	11	43	
Percent of total	12	5	40	19	23	2	75	25		

Bins oriented long axis north-south.

Effect of Different Management Practices on Insect Populations in Wheat Stored in Ever-Normal Granary Type Bins

During the past quarter a summary has been prepared showing the trends of insect populations in different lots of wheat stored under different management practices at Hutchinson, Kansas, since the project was started in the summer of 1941. The data are presented in table 5. From the results to date, it appears that the following management practices are effective in preventing serious insect infestation:

1. Fumigation twice annually, in August and October.
2. Bins with walls and roofs painted white.
3. Fumigation in August or September.
4. Turn, clean, and fumigate in September.

It is of interest to note that wheat of less than 11 percent moisture content has been stored without serious insect infestation, while grain of 11-12 percent moisture has become seriously infested.

The lesser grain borer has been the most serious pest of the grain stored at the Hutchinson Experimental Wheat Storage site. For this reason the evaluation of the effectiveness of a management practice is based largely on infestation by this species.

Fumigation in August or September now appears to be nearly as effective as two fumigations yearly in August and October. If so, this practice will reduce the cost of maintenance by one-half. While turning, cleaning, and fumigating is highly effective in preventing insect infestation, the cost is high and should be used only when necessary to put the grain in condition for fumigation.

Table 5: -- Comparison of infestations in wheat stored under different management practices, Hutchinson, Kansas, 1941-1944.

Management Practice.	Average number of insects per 1000-gram average sample									
	1941	1942				1943				1944
Steel bins	Oct.	Jan.	Apr.	June	Oct.	Jan.	Apr.	Aug.	Oct.	Jan.
Fumigation twice annually	0.6*	T 1.7	0.3	0.4	T 0.6	0.9	0.6	0.3	T 0.1	T 0.06
	0.1**	0.5	0.4	0.6	0.0	0.2	0.0	0.0	0.0	0.0
Turn, clean, and fumigate IN in September							0.4	9.4	T 0.2	0.3
							0.2	0.1	0.0	0.1
White walls and roof	0.0	1.0	0.0	0.0	1.0	0.2	0.0	1.1	2.2	0.7
	0.0	0.5	0.0	0.0	1.5	0.0	0.0	0.0	0.3	0.0
White and grouped for shading							0.9	2.1	3.3	3.7
							0.0	0.0	0.0	0.0
White and surface insulation							0.0	0.9	4.5	1.4
							0.0	0.0	0.0	0.0
Surface insulation							0.0	24.5	16.5	8.7
							0.0	0.3	0.3	0.0
Fumigation in August					4.2	1.6	2.0	T 0.5	3.3	1.8
					1.5	0.2	0.0	0.1	2.3	0.0
Fumigation in September					0.3	0.7	0.3	12.5	T 0.6	0.5
					0.3	0.0	0.0	5.1	0.2	0.0
Fumigation in October								18.0	T 0.9	1.1
								1.9	0.2	0.1

(continued)

Table 5 (continued)

Management Practice.	Average number of insects per 1000-gram average sample									
	1941	1942				1943				1944
Steel bins	Oct.	Jan.	Apr.	June	Oct.	Jan.	Apr.	Aug.	Oct.	Jan.
Turning in January		T 1.4	1.6	0.5	9.4	T 19.0	1.2	12.5	13.2	T 5.7
		0.5	0.0	0.0	1.4	24.0	2.2	0.1	3.0	6.5
No treatment:										
9-10% moisture								0.0	0.2	0.0
								0.0	0.0	0.0
10-11% moisture	0.2	0.2	0.2	0.1	2.2	2.8	1.0	4.5	4.7	0.6
	0.0	0.0	0.0	0.0	0.4	0.4	0.0	0.4	2.7	0.4
11-12% moisture	4.8	6.6	1.5	0.0	11.5	7.6	1.5	19.8	17.8	1.9
	48.7	1.2	0.5	0.0	3.9	0.7	0.1	0.6	4.4	0.6
12-12½% moisture									7.0	2.0
									0.9	0.2
12½-14% moisture ***									18.5	38.5
									84.8	8.6
Turn and clean when necessary						T 5.4	0.1	18.9	T 8.3	(Terminated)
						0.5	0.0	1.7	9.7	
Surface oil spray		T 0.4	0.5	T --	T 12.5	0.2	0.4	T --	T 8.5	(Terminated)
		0.0	0.1	--	1.7	0.0	0.0	--	9.0	

(continued)

Table 5 (continued)

Management practice.	Average number of insects per 1000-gram average sample									
	1941	1942				1943				1944
Wooden bins	Oct.	Jan.	Apr.	June	Oct.	Jan.	Apr.	Aug.	Oct.	Jan.
White walls and roof						0.0	0.0	1.8	0.9	0.5
						0.0	0.0	0.0	0.0	0.0
White walls						0.0	0.0	1.5	3.6	1.1
						0.0	0.0	0.7	0.4	0.0
Red walls						0.0	0.0	6.5	8.4	2.2
						0.0	0.0	1.0	3.5	0.0

* = Bran bugs: all species except the weevils.

** = Weevils: includes lesser grain borer, rice weevil, and granary weevil.

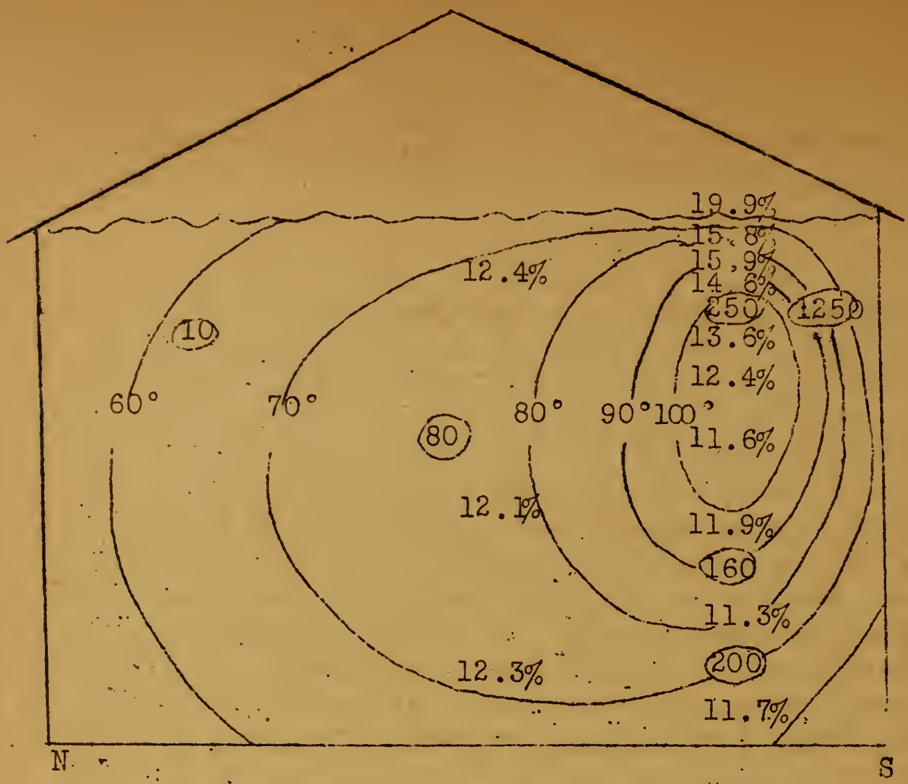
*** = Wheat stored in ventilated bins.

T = Designated treatment applied.

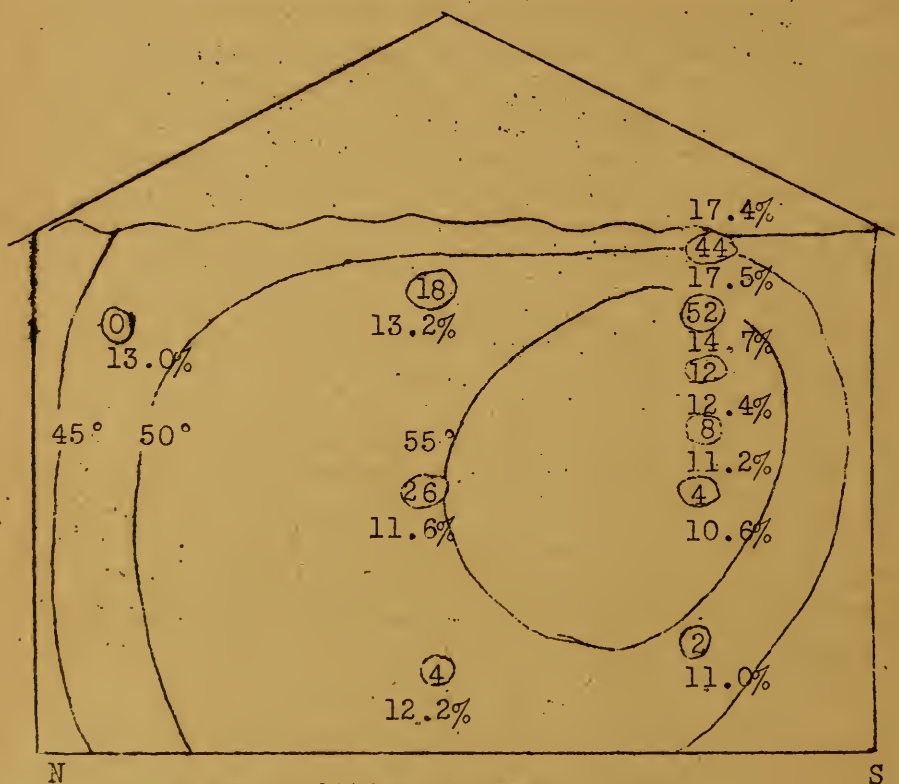
Further Observations on the Temperature-Moisture-Insect Relationships in Wheat Stored in Steel Bins

There was included in a previous report a discussion of the effect of insect populations on the temperature and moisture of grain stored in a steel bin at Chase, Kansas. This bin was inspected again on March 10, 1944 and a series of samples and temperature readings were taken to determine changes in the temperature-moisture-insect conditions. The bin was fumigated early in December, 1943. The differences in temperature, moisture, and insect populations are given in figure 1, A and B. It may be noted that fumigation reduced the insect population and this reduction coupled with the action of winter temperatures resulted in a general lowering of the temperatures. In uninfested bins in March the warmest grain is in the central portion of the grain mass, whereas in the bin under discussion the warmest grain was found about midway between the center of the bin and the south wall.

During January two bins on the Hutchinson site developed abnormally high temperatures because of insect infestation, and the surfaces became crusted over the center of infestation which was located about three feet from the south wall. Samples were drawn from each of the bins at 6-inch intervals in a vertical column through the infested portion of the grain. The moisture content and insect population was determined for each 6-inch interval from the top to the bottom of the bin. Temperatures were taken at intervals in a vertical column through the infested portion. The crusted surface was removed and the bins were then fumigated, one with carbon tetrachloride and the other with trichlorethylene at a dosage of 3 gallons per 1000 bushels. The results are summarized in tables 6 and 7. The moisture gradients in these bins are typical for infested bins--high moisture in the surface grain, with low moisture in the center of infestation. The grain in both bins contained much "flour" milled by the insects and this condition imposed a severe test for the fumigants. It may be noted that good results were obtained with both carbon tetrachloride and trichlorethylene, the insect mortality being 100 percent and 93 percent respectively for the two materials.



A -- Condition in November, 1943



B -- Condition in March, 1944

Fig. 1:--Temperature and moisture conditions in relation to insect infestation in wheat stored in a 2000-bu. steel bin, Chase, Kansas.

Legend: Figures inside circles are number of insects per 1000 grams. Moisture gradients in percent. Temperatures in degrees F.

Table 6:--Number of insects per 1000-gram sample in Bin 8-1 before and after fumigation, Hutchinson, Kans. Fumigated with trichlorethylene, 3 gallons per 1000 bushels, January 31, 1944.

Sampling level (inches)	Moisture (per-cent)	Insect damage (%)	Number of insects per 1000 grams: Before fumigation, January 31, 1944: Weevils	Bran bugs	Total	After fumigation, February 23, 1944: Weevils	Bran bugs	Total	After fumigation, March 10, 1944: Weevils	Bran bugs	Total	Temperature 3 feet from south wall: 1/31	2/23	3/11
0-6	17.6	40.0	1220	72	1292	Caked grain removed before fumigation								
6-12	16.0	43.0	152	196	348	Caked grain removed before fumigation								
12-18	13.7	14.0	24	36	60	Caked grain removed before fumigation						104	48	52
18-24	12.1	22.4	16	4	20	0	0	0	0	0	0			
24-30	11.2	4.5	4	4	8	0	0	0	0	0	0			
30-36	10.8	4.3	0	0	0	0	0	0	0	0	0			
36-42	10.5	2.4	4	4	8	0	0	0	0	0	0			
42-48	10.3	3.2	4	4	8	0	0	0	0	0	0			
48-54	10.2	5.4	16	0	16	0	0	0	0	0	0			
54-60	10.0	1.8	40	0	40	0	0	0	16	12	28			
60-66	9.5	2.2	0	0	0	4	8	12	60	64	124	107	70	65
66-72	9.6	2.3	24	0	24	12	12	24	68	32	100			
72-78	9.3	4.0	32	0	32	48	28	76	0	0	0			
78-84	9.4	2.7	48	0	48	76	52	128	0	0	0			
84-90	9.4	4.7	8	0	8	0	4	4	0	0	0			
90-96	9.4	3.0	320	48	368	0	0	0	28	24	52			
96-102	9.7	0.4	644	24	668	0	0	0	0	0	0			
102-108	9.6	1.3	260	0	260	0	0	0	0	0	0	100	87	75
108-114	9.6	0.6	128	0	128	0	0	0	0	0	0			
114-120	9.7	1.0	36	8	44	0	0	0	0	0	0			
120-126	9.6	1.0	12	4	16	0	4	4	0	0	0			
126-132	9.6	1.0	44	0	44	0	0	0	0	0	0			
132-138	9.7	1.0	24	4	28	0	0	0	0	0	0			
138-144	9.9	1.0	36	8	44	0	0	0	0	0	0			
144-150	10.2	1.0	24	0	24	0	0	0	0	0	0	54	56	52
Totals			3116	420	3536	140	108	248	172	132	304			

Note: "Weevils" include lesser grain borer, rice weevil, granary weevil. The lesser grain borer was dominant in this bin. "Bran bugs" include all other species.

Table 7:--Number of insects per 1000-gram sample in Bin 11-7 before and after fumigation, Hutchinson, Kansas. Fumigated with carbon tetrachloride, 3 gallons per 1000 bushels, January 31, 1944.

	Number of insects per 1000 grams								
	Before fumigation 1/31				After fumigation 2/23			Temperature	
Sampling level (inches)	Moisture (%)	Weevils	Bran bugs	Total	Weevils	Bran bugs	Total	1/31	2/23
0-6	25.0	16	228	244	Cake removed before fumigation			82	
6-12	17.8	0	264	264					
12-18	15.4	4	248	252	0	0	0		
18-24	12.3	0	144	144	0	0	0	93	
24-30	10.9	0	40	40	0	0	0		58
30-36	10.6	0	32	32	0	0	0		
36-42	10.4	4	92	96	0	0	0		
42-48	10.1	8	100	108	0	0	0	89	
49-54	9.7	16	136	152	0	0	0		62
54-60	9.6	20	76	96	0	0	0		
60-66	8.8	44	232	276	0	0	0		
66-72	8.8	52	128	180	0	0	0	79	
72-78	9.6	40	296	336	0	0	0		59
78-84	10.1	96	116	212	0	0	0		
84-90	10.5	12	68	80	0	0	0		
90-96	10.6	4	4	8	0	0	0	66	
96-102	10.7	0	8	8	0	0	0		55
102-108	10.8	0	8	8	0	0	0		
108-114	10.8	0	0	0	0	0	0		
114-120	10.8	4	0	4	0	0	0	56	
120-126	10.9	0	0	0	0	0	0		52
126-132	10.9	0	0	0	0	0	0		
132-138	10.9	0	0	0	0	0	0		
138-144	10.9	0	0	0	0	0	0	49	
144-150	10.9	0	0	0	0	0	0		46
Totals		320	2220	2544	0	0	0		

Note: "Weevils" include lesser grain borer, rice weevil, granary weevil. "Bran bugs" include all other species. The long-headed flour beetle and its larvae were dominant in this bin.

Experimental Fumigation and Dust Treatment of Stored Wheat

Tests with Trichloroethylene and Carbon Tetrachloride

As indicated in tables 6 and 7, a trial of trichloroethylene was made in bin 8-1 using carbon tetrachloride as a check in bin 11-7. Good results were obtained with both materials even though they were used under severe conditions. Further tests with trichloroethylene are planned.

One additional test with carbon tetrachloride was made in bin 2-3. The grain in this bin had been moved from bin 2-2 which had become heavily infested with rice weevils. Both bins have perforated side walls and floors and past experience had shown that fumigation of grain in bins of this type of construction was impracticable. In order to fumigate the grain effectively, bin 2-3 was lined with Sisalkraft paper prior to filling from 2-2. The grain was then fumigated with a dosage of 3 gallons of carbon tetrachloride per 1000 bushels. The infestation per 1000 grams before and after fumigation was as follows:

Before fumigation, March 4, 1944		After fumigation, March 18, 1944	
Rice weevil	97	Lesser grain borer	1
Lesser grain borer	38	Total	1
Red flour beetle	29		
Flat grain beetle	17		
Long-headed flour beetle	1		
Total	182	Mortality	99.4 percent

Test with Almicide Dust

A 150-bushel lot of grain heavily infested with rice weevil, lesser grain borer, and red flour beetle was dusted with almicide dust at the rate of 8 lbs. per 100 bushels. As the grain passed through the elevator the dust was shaken onto the grain. In passing through the elevator and falling into the bin, the dust was thoroughly mixed with the grain. The treatment was applied on March 2, 1944, and samples of both treated and untreated grain were examined immediately after treatment and at 48-hour intervals after treatment for a period of 8 days. The results are given in table 8. Unfortunately a period of cold weather occurred immediately after treatment with the result that the grain cooled rapidly and about half of the insects died from exposure to cold. However, from the table it will be seen that mortality in the treated grain was much higher than in the untreated check. It is planned to make further tests with this dust during warm weather.

Table 8: --Results of treatment of wheat with almicide dust, Hutchinson, Kansas, March, 1944.

Date	Number living insects per 1000 grams		Mortality percent		Remarks
	Untreated check	Treated	Untreated check	Treated	
3-2	204	140	-	-	Immediately after treat-
3-4	132	15	35	89	ment percent mortality
3-6	52	0	74	100	figured on basis of number
3-8	62	4	69	97	of insects per 1000 grams
3-10	110	3	56	98	in original sample.

A sample of both the treated and untreated wheat was submitted to the Chicago Board of Review for grade determination. The untreated sample was designated as "Sample grade hard winter, weevily, musty". The treated sample was graded "No. 5 hard winter, dockage 1%" with the notation "Due to treatment, odor cannot be accurately determined."

The price of treated wheat is penalized 5 to 15 cents per bushel on the market.

Effects of Fumigants on Germination and Baking and Milling Qualities of Wheat*

Previous reports on this project have been made in 1943 on pages 13-16 of Report No. 9 and on pages 37-40 of Report No. 10.

Germination data given in tables 9, 10, and 11 indicate changes in viability of 10.5, 12.5, and 14% moisture wheat as affected by fumigation with common grain fumigants and subsequent storage of aerated and non-aerated samples for 7 months.

By comparison of the germination data with data of previous reports it will be noted that little change in viability has occurred during the past 3 months of storage.

Since serious injury to germination from normal dosages of grain fumigants was sustained only by the 14% moisture wheat it was decided to make baking tests of this series at the end of 7 months of storage. The results of these baking tests are given in table 12.

Table 9: -- Effect of fumigants on germination as influenced by dosage, grain moisture, length of exposure, etc.

Fumigant and Dosage per 1000 bushels		Percentage of germination of 10.5 percent moisture wheat					
		Not aerated			Aerated		
		5 Months	6 Months	7 Months	5 Months	6 Months	7 Months
Methyl bromide	40 lbs.				4	6	4
Chloropicrin	40 lbs.				3	4	4
Cyanogas	15 lbs.	95	97	94	96	95	95
Dowfume 75	6 gals.	95	96	95	95	96	98
Carbon disulphide	3 gals.	89	96	96	95	95	94
Carbon disulphide + CCl_4	3 gals.	95	95	97	97	96	94
Carbon disulphide + CCl_4	6 gals.	91	96	92	95	94	95
Ethide + CCl_4	1 gal.	94	98	90	98	94	94
Chloropicrin + CCl_4	1 gal.	84	89	82	91	92	91
Dowfume Br 10	2 gals.	90	91	90	96	98	96
Check					94	95	97

* - Reported by R. T. Cotton and J. C. Frankenfeld.

Table 10: -- Effect of fumigants on germination as influenced by dosage, grain moisture, length of exposure, etc.

Fumigant and Dosage per 1000 bushels		Percentage of germination of 12.5 percent moisture wheat					
		Not aerated			Aerated		
		5 Months	6 Months	7 Months	5 Months	6 Months	7 Months
Methyl bromide	40 lbs.				0	0	0
Chloropicrin	40 lbs.				9	9	9
Cyanogas	15 lbs.	93	90	93	91	92	92
Dowfume 75	6 gals.	89	92	95	92	94	93
Carbon disulphide	3 gals.	76	83	89	94	96	92
Carbon disulphide + CCl_4	3 gals.	95	93	95	91	92	96
Carbon disulphide + CCl_4	6 gals.	83	86	93	91	92	94
Ethide + CCl_4	1 gal.	83	85	89	92	90	92
Chloropicrin + CCl_4	1 gal.	77	74	84	90	89	89
Dowfume Br 10	2 gals.	70	71	76	93	90	92
Check					96	95	94

Table 11: -- Effect of fumigants on germination as influenced by dosage, grain moisture, length of exposure, etc.

Fumigant and Dosage per 1000 bushels		Percentage of germination of 14 percent moisture wheat					
		Not aerated			Aerated		
		5 Months	6 Months	7 Months	5 Months	6 Months	7 Months
Methyl bromide	40 lbs.				0	0	0
Chloropicrin	40 lbs.				20	7	14
Cyanogas	15 lbs.	96	94	97	91	92	94
Dowfume 75	6 gals.	84	91	93	92	94	94
Carbon disulphide	3 gals.	64	60	82	89	94	94
Carbon disulphide + CCl_4	3 gals.	82	91	95	92	94	94
Carbon disulphide + CCl_4	6 gals.	76	86	81	89	93	94
Ethide + CCl_4	1 gal.	67	73	76	89	92	96
Chloropicrin + CCl_4	1 gal.	37	39	36	67	79	68
Dowfume Br 10	2 gals.	50	39	56	91	93	94
Check					90	82	44*

* Reduction in germination due to rice weevil infestation.

Table 12: -- Baking values of 14% moisture wheat samples 7 months after initial exposure to fumigation.*

Dosage of fumigant per 1000 bushels	Grain moisture	Flour[1/] protein %	Flour[1/] ash %	Mixing time minutes	Absorption[1/] 15% M. B. %	Loaf[2/] volume cc	Crumb[3/] color	Texture[4/] grain	Odors[5/]
Samples aerated after 24 hours' exposure									
0 lbs. methyl bromide	13.8	10.7	.45	2.2	63	768	83 cy	80-o	++
0 lbs. chloropicrin	13.9	10.7	.44	2.2	63	774	83 cy	81-c	++++
5 lbs. Cyanogas	13.8	10.7	.42	2.2	63	819	83 cy	81-o	++
gals. Carbon disulphide	13.3	10.5	.42	2.2	63	782	83 cy	82-o	
gals. CS_2 - CCl_4 (1-4) mixture	13.5	10.5	.42	2.2	63	768	83 cy	82-o	
gals. CS_2 - CCl_4 (1-4) mixture	13.5	10.6	.41	2.2	63	756	83 cy	83-o	
gal.(3# Ethide in CCl_4 to make 1 gallon)	13.8	10.4	.41	2.2	63	765	83 cy	82-o	
gal.(3# chloropicrin in CCl_4 to make 1 gal.)	13.5	10.2	.40	2.2	63	779	83 cy	82-o	
gals. Ethylene dichloride-CCl_4(3-1)mixture	13.5	10.6	.42	2.2	63	813	83 cy	82-o	+
gals. Dowfume Br 10	13.5	10.5	.41	2.2	63	751	83 cy	82-o	
heck	13.9	11.1	.43	2.2	63	804	83 cy	82-o	
Samples not aerated									
5 lbs. Cyanogas	13.5	10.5	.42	2.2	63	776	83 cy	82-o	
gals. Carbon disulphide	13.6	10.5	.41	2.2	63	697	83 cy	81-o	+
gals. CS_2 - CCl_4 (1-4) mixture	13.6	10.7	.42	2.2	63	753	83 cy	82-o	
gals. CS_2 - CCl_4 (1-4) mixture	13.7	10.5	.42	2.2	63	747	83 cy	82-o	
gal.(3# Ethide in CCl_4 to make 1 gallon)	13.6	10.6	.43	2.2	63	774	83 cy	82-o	
gal.(3# Chloropicrin in CCl_4 to make 1 gal.)	13.6	10.5	.41	2.2	63	777	83 cy	82-c	
gals. Ethylene dichloride-CCl_4(3-1)mixture	13.5	10.6	.43	2.2	63	778	83 cy	81-o	+++
gals. Dowfume Br 10	13.6	10.3	.40	2.2	63	763	83 cy	82-o	

1/ = 15% moisture basis
2/ = Average of (3x2) loaves
3/ = cy = creamy yellow
4/ = o = open; c = closed
5/ = Average opinion of 4 people

Baking method: -- Malt-phosphate-bromate plus 3% shortening.

* -- In cooperation with the Milling Department of Kansas State College.

The data of table 12 would appear to indicate that damage to germination as a result of fumigation does not affect the baking quality since wheat with a nearly zero germination bakes almost as well after 7 months storage as the check or untreated sample. Non aerated samples appear to be affected adversely, probably as a result of the retention of the fumigant. This was particularly evident in the case of the non-aerated sample of carbon disulphide treated wheat.

Of interest in connection with the above study are the results obtained in connection with the longtime storage of wheat that is fumigated regularly. The results of two bins of wheat stored at Hutchinson, Kansas from July, 1941 to June, 1943 are given below. The records show that as a result of repeated fumigations over a two-year period the germination of the stored wheat gradually drops to a point near zero. Bin 1-16 was fumigated 6 times during the two year period yet baking values as indicated by two different methods of baking showed no significant change after 2 years of storage. Bin 2-13 was fumigated 7 times during the same period with the result that a significant reduction in loaf volume was evident at the end of the 2-year period. This may have resulted from the retention of some of the chemicals used in fumigation.

Record of Bin 1-16

The wheat was placed in this bin in July, 1941.

It was fumigated 7-20-41 with carbon disulphide at the rate of 3 gallons per 1,000 bushels.

It was subsequently fumigated as follows:

6-11-42 with ethylene dichloride-carbon tetrachloride 3-1 mixture, 5 gallons per 1,000 bushels.
8-3-42 with ethylene dichloride 90%-methyl bromide 10% - 2 gallons per 1000 bushels.
11-24-42 with ethylene dichloride-carbon tetrachloride 3-1 mixture 5 gallons per 1,000 bushels.
2-6-43 with chloropicrin 2 lbs. in carbon tetrachloride to make 1 gallon -- 1 gallon per 1,000 bushels.
6-12-43 with chloropicrin 2 lbs. in carbon tetrachloride to make 1 gallon -- 2 gallons per 1,000 bushels.

Baking values of wheat sampled

Baking Method Number 2*	Date sample taken 6 - 19 - 41	8 - 13 - 42	6 - 12 - 43
Water absorption	60%	60%	60%
Volume of loaf	632cc	643cc	606cc
Wt. of loaf		153 grams	153 grams
Color of crumb	75cr	75cr	75 cr
Grain and texture	80vg	70 g	70 F
Color of crust	B	DB	DB
Baking Method Number 3a			
Water absorption	60%	60%	60%
Volume of loaf	656cc	683cc	683cc
Wt. of loaf		149 grams	150 grams
Color of crumb	75cr	80 cr	80 cr
Grain and texture	85vg	80 g	85 g
Color of crust	B	DB	DB
Germination	1941	1942	1943
	83.5%	April--75.25%	January--35%
		July --65.25%	April --19%
			June --28%
			June 19-- 1%

* - U.S.D.A. Baking and Milling Laboratory, Washington, D.C.

Record of Bin 2-16

The wheat was placed in this bin in July, 1941.
It was fumigated 7-20-41 with carbon disulphide, 3 gals. per 1000 bu.
It was subsequently fumigated as follows:

10-4-41 with Cyanogas, 20 lbs. per 1000 bushels.
6-16-42 with Dowfume Br 10, $1\frac{1}{2}$ gals. per 1000 bushels.
7-6-42 with Dowfume Br 10s, 2 gals. per 1000 bushels.
11-24-42 with Dowfume 75, 4 gals. per 1000 bushels.
2-6-43 with Chloropicrin-CCl_4 mixture, 2 gals. per 1000 bushels.
6-12-43 with Chloropicrin-CCl_4 mixture, 2 gals. per 1000 bushels.

Baking values of wheat

Baking Method Number 2	Date sample taken 6-19-41	6-8-42	6-12-43	6-19-43
Water absorption	60	60	60	60
Volume cc	660	602	567	561
Color of crust	DB	DB	DB	DB
Grain and texture	80 vg	70 F	65 F	70 g
Color of crumb	75 cr	70 cr	70 cr	75 cr
Whole wheat fat acidity	21.59	24.2	37.2	43.3
Ash flour	.457	.50	.54	.46
Baking Method Number 3a				
Water absorption	60	60	60	60
Volume cc	674	683	646	643
Color of crust	DB	DB	DB	DB
Grain and texture	80 vg	85 vg	80 g	80 g
Color of crumb	80 cr	80 cr	85 cr	85 cr
Whole wheat fat acidity	21.59	24.2	37.2	43.3
Ash flour	.457	.50	.54	.46

Germination	1941	1942	1943
	Aug.-82.5%	Apr.--83%	Jan. -- 29%
		July-68.75%	May -- 2%
			June 12-31%
			June 19- 2%

Effect of the Amount of Dockage on the Ability of T. Confusum to Survive and Reproduce in Wheat of Various Moisture Content.*

Due to the inconsistency of the data, recorded in Report No. 10, in the 85° F. series, a new set of tests were repeated at this temperature. This set of tests has been in operation for 5 weeks and the percentage of survival and the number of pupae recovered for that period are summarized in table 13.

Although this series of tests has not been in progress for a long enough period to either substantiate or discredit the results obtained in the previous test, the general tendency follows rather closely that of our previous tests. That is, that, except for the clean wheat in the 9% moisture lot, there is little significant difference in the percentage of survival due to either the moisture content of the wheat, or the amount of dockage present.

Continuing these investigations, another series was set up, using the same moisture and dockage variants, at a constant temperature of 90° F. The percentage of survival and the number of pupae recovered over a period of seven weeks are summarized in table 14.

Here again our previous conclusions hold true, that is, that the moisture content of the wheat and the amount of dockage have no effect upon the survival of the adults, except that in the 9% moisture lot the survival in clean wheat is considerably reduced.

From the standpoint of reproduction, both the moisture content of the wheat and the amount of dockage are important, and at 90° F. the same general tendency holds true, that is, that as the moisture of the wheat and the amount of dockage is increased, the total number of pupae recovered is also increased.

The decided decrease in survival together with the resulting reduction in pupae recovery in the 12% moisture series is not explainable. Since the only variable in the lots in this series is the amount of dockage, there appears to be no plausible explanation for the high percentage of mortality noticed in four of the lots of this series.

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* - Reported by R. T. Cotton and J. C. Frankenfeld.

Table 13: -- Survival of T. confusum in 9, 12, and 15% moisture wheat with various amounts of dockage at 85° F.

Rearing media	Percentage of survival after 1 Week	2 Weeks	3 Weeks	4 Weeks	5 Weeks	No. of pupae recovered
9% Wheat						
Clean wheat berries	97	96	85	76	61	0
Same plus 0.5% dockage	96	95	94	92	92	0
" " 1.0% "	95	91	86	86	86	1
" " 2.0% "	94	93	89	87	86	2
" " 4.0% "	99	94	92	91	91	3
" " 8.0% "	94	93	91	89	89	6
12% Wheat						
Clean wheat berries	99	94	90	90	90	0
Same plus 0.5% dockage	96	94	94	94	93	0
" " 1.0% "	99	96	96	96	96	11
" " 2.0% "	99	93	93	93	93	20
" " 4.0% "	98	94	94	94	94	37
" " 8.0% "	99	95	93	93	88	36
15% Wheat						
Clean wheat berries	96	96	95	95	95	1
Same plus 0.5% dockage	100	96	93	92	92	5
" " 1.0% "	100	98	96	96	96	49
" " 2.0% "	99	94	93	93	93	131
" " 4.0% "	98	95	95	95	94	91
" " 8.0% "	97	93	92	90	90	220

Table 14: -- Survival of T. confusum in 9, 12, and 15% moisture wheat with various amounts of dockage at 90° F.

Rearing Media	Percentage of survival after 1 Week	2 Weeks	3 Weeks	4 Weeks	5 Weeks	6 Weeks	7 Weeks	No. of pupae recovered
9% Wheat								
Clean wheat berries	99	93	80	74	67	49	38	0
Same plus 0.5% dockage	100	98	95	93	90	86	83	1
" " 1.0% "	100	94	90	90	88	87	87	5
" " 2.0% "	100	99	95	95	92	92	92	36
" " 4.0% "	100	96	96	96	94	94	91	53
" " 8.0% "	99	99	99	99	96	94	93	232
12% Wheat								
Clean wheat berries	100	94	91	87	78	69	69	12
Same plus 0.5% dockage	99	98	94	94	92	36	33	11
" " 1.0% "	100	95	92	90	88	5		20
" " 2.0% "	97	95	90	89	88	0		43
" " 4.0% "	99	99	94	92	92	0		35
" " 8.0% "	100	99	98	98	98	98	96	669
15% Wheat								
Clean wheat berries	100	95	94	92	90	86	84	39
Same plus 0.5% dockage	99	98	93	92	92	91	91	109
" " 1.0% "	100	99	97	96	94	94	94	162
" " 2.0% "	100	97	95	94	93	93	93	362
" " 4.0% "	99	99	98	98	98	98	97	600
" " 8.0% "	100	100	98	97	95	95	94	740

Effect of Grain Moisture and Temperature on the Survival and Reproduction of the Granary and Rice Weevils*

In order to verify our results obtained in a previous test, two series of tests held at 80 and 85° F. were repeated. In these tests 12, 13, and 14% moisture content wheats were used, but the tests were confined to only the granary and the rice weevil. By repeating these tests at this time, we are able to note any significant differences due to conditions which cannot be controlled, such as the season of the year, variations in the insects themselves, and variations in the food used. The first series was conducted during the summer months on the 1942 crop wheat. This series was conducted during the winter months, and on the 1943 wheat crop.

In the series of tests herewith reported, two lots of each insect were used for each moisture variant. Tables 15 and 16 summarize the percentage of survival of the various lots over a period of 19 weeks. It will be noted that while there are some differences in the percentage of survival in the two complementary lots, in each moisture series the general tendency is the same, that is, that as the moisture content is increased the percentage of survival is also increased. This holds true for both the 80 and 85° F. series. There is no consistent difference in the percentage of survival at 80 or 85° F.

Comparing these results with the results of the previous tests mentioned above, we find considerable variations in the percentage of survival.

Although not consistently so, the general tendency is for a higher percentage of survival, in the case of the granary weevil, in the tests conducted in the summer of 1943 as compared with the series completed this winter. The exact reverse is true in the case of the rice weevil. Also, it should be noted that the rice weevil showed a decreased percentage of survival as the moisture content of the wheat was increased in the first series of tests while this time the reverse was true. With the granary weevil the tendency was the same in both series.

Since the results on reproduction are not complete for the second series of tests the differences in the percentage of survival in themselves are not significant, for it was shown in the earlier series that reproduction increased as the moisture content of the wheat was increased.

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* - Reported by R. T. Cotton and J. C. Frankenfeld.

Continuing our studies on the effect of moisture and temperature on the granary and rice weevil, another series of tests were conducted at 65° F. In this series both wheat and corn were used as food, with a moisture content of 12, 13, and 14%. Two replicate lots for each species were used for each moisture and food variant. The results of the percentage of survival over a period of 17 weeks are summarized in tables 17 and 18.

Again the general tendency is toward increased survival with an increased moisture content of the grain. Also, there seems to be a slight increase in survival in favor of corn as food, as compared with wheat.

Although reproduction records are not complete, indications are that there will be a fairly heavy reproduction of rice weevil, with only a slight and variable amount of reproduction by the granary weevil.

Table 15:--Survival of granary and rice weevil in 12, 13, and 14% moisture wheat at 80° F.

Insect used	Percentage of survival after									
	1 Week	3 Weeks	5 Weeks	7 Weeks	9 Weeks	11 Weeks	13 Weeks	15 Weeks	17 Weeks	19 Weeks
12% Wheat										
Granary weevil	100	98	94	87	78	62	41	28	18	9
" "	100	98	98	91	83	78	68	40	23	9
Rice weevil	100	100	99	98	94	82	47	29	14	2
" "	100	99	97	94	93	89	76	28	20	6
13% Wheat										
Granary weevil	100	100	95	90	84	74	60	37	26	14
" "	100	99	98	92	91	84	74	52	41	27
Rice weevil	100	96	95	92	90	83	67	37	31	16
" "	100	84	83	83	79	71	62	28	21	8
14% Wheat										
Granary weevil	100	96	96	91	84	72	59	47	34	24
" "	100	99	96	91	89	82	74	61	38	28
Rice weevil	100	95	92	89	84	77	70	55	41	27
" "	100	91	89	87	69	66	60	50	42	24

Table 16:--Survival of granary and rice weevil in 12, 13, and 14% moisture wheat at 85° F.

Insect used	Percentage of survival after									
	1 Week	3 Weeks	5 Weeks	7 Weeks	9 Weeks	11 Weeks	13 Weeks	15 Weeks	17 Weeks	19 Weeks
12% Wheat										
Granary weevil	100	100	99	97	96	91	81	54	49	32
" "	100	97	97	91	88	83	70	37	29	14
Rice weevil	100	100	99	92	84	71	51	24	10	2
" "	100	97	93	88	88	82	68	15	8	0
13% Wheat										
Granary weevil	100	97	95	90	86	76	65	47	35	24
" "	100	97	97	90	89	84	76	40	34	22
Rice weevil	100	100	99	94	92	87	66	47	40	17
" "	100	93	91	91	89	75	72	41	32	5
14% Wheat										
Granary weevil	100	97	96	96	93	90	82	67	52	43
" "	100	99	96	93	81	69	63	47	37	27
Rice weevil	100	97	94	92	90	85	73	55	42	21
" "	100	85	82	79	77	77	68	59	44	31

Table 17:--Survival of granary and rice weevil in 12, 13, and 14% moisture corn at 65° F.

Insect used	1 Week	3 Weeks	5 Weeks	7 Weeks	9 Weeks	11 Weeks	13 Weeks	15 Weeks	17 Weeks
	Percentage of survival after								
12% Corn									
Granary weevil	100	98	92	92	88	84	80	78	66
" "	100	94	94	92	88	86	86	82	70
Rice weevil	100	100	96	96	92	92	88	80	64
" "	100	98	88	88	88	88	84	68	46
13% Corn									
Granary weevil	100	94	80	80	78	76	72	70	64
" "	100	94	94	90	86	84	82	82	80
Rice weevil	100	96	92	88	78	76	70	64	62
" "	100	92	90	90	80	76	68	62	60
14% Corn									
Granary weevil	100	92	90	88	88	86	86	86	76
" "	100	98	94	92	90	90	90	90	90
Rice weevil	100	100	98	88	88	86	82	80	78
" "	100	100	98	96	94	92	88	82	82

Table 18:--Survival of granary and rice weevil in 12, 13, and 14% moisture wheat at 65° F.

Insect used	1 Week	3 Weeks	5 Weeks	7 Weeks	9 Weeks	11 Weeks	13 Weeks	15 Weeks	17 Weeks
	Percentage of survival after								
12% Wheat									
Granary weevil	100	96	96	94	80	76	76	70	66
" "	100	94	90	84	82	78	78	70	60
Rice weevil	100	98	94	88	88	78	70	62	32
" "	100	100	100	100	96	92	84	74	40
13% Wheat									
Granary weevil	100	100	96	96	92	90	88	86	80
" "	100	96	96	94	92	92	84	82	82
Rice weevil	100	96	96	96	90	90	86	84	76
" "	100	100	96	96	92	88	80	78	76
14% Wheat									
Granary weevil	100	96	94	90	88	88	88	88	86
" "	100	90	90	84	78	74	74	74	66
Rice weevil	100	96	90	90	86	76	74	68	66
" "	100	98	80	70	70	70	66	64	64

Injury to Whole Wheat Berries by *Tribolium confusum**

In the past it has generally been accepted that the confused flour beetle does not injure the whole wheat berry, and that its feeding, when found in wheat, was confined to the cracked berries or other dockage mixed with the wheat. In our tests to determine the effect of dockage in wheat on the survival and reproduction of *T. confusum*, we have often observed that many of the wheat berries have had the germ completely removed. Also, after a few weeks' exposure a considerable amount of grain dust was found in the clean wheat lot, indicating feeding on the wheat by *T. confusum*.

To determine to what extent the wheat is damaged by this insect, 500 wheat berries from each of the moisture-dockage variant lots were examined, after the wheat had been exposed for 19 weeks. The percentage of berries which had their germ removed by the feeding of *T. confusum* in the various lots varied from 2.4% to 39.6%. While not conclusively established the general tendency is that the higher the moisture content of the wheat, the greater is the percentage of damage to the germ.

Careful examination revealed no other injury to the wheat berry, indicating that the insect is unable to gnaw through the bran layer except around the germ. Once the germ has been removed, the insect can and does feed upon the endosperm through the entrance gained by removal of the germ.